

What is claimed is:

1. A composite article comprising aerogel and a reinforcing structure to serve as a flexible, durable, light-weight insulation product wherein the reinforcing structure comprises a lofty fibrous batting which causes no substantial degradation of the thermal performance of the aerogel as compared with a non-reinforced aerogel body of the same material.

2. The composite of Claim 1, wherein the aerogel is selected from the group consisting of inorganic and organic gel forming materials.

3. The composite of Claim 1, wherein the inorganic gel forming material is selected from the group consisting of zirconia, yttria, hafnia, alumina, titania, ceria, and silica, and any combination thereof.

4. The composite of Claim 1, wherein the organic gel forming material is selected from the group consisting of polyacrylates, polystyrenes, polyacrylonitriles, polyurethanes, polyimides, polyfurfural alcohol, phenol furfuryl alcohol, melamine formaldehydes, resorcinol formaldehydes, cresol formaldehyde, phenol formaldehyde, polyvinyl alcohol dialdehyde, polycyanurates, polyacrylamides, various epoxies, agar, and agarose, and combination thereof.

5. The composite of Claim 1, wherein the lofty fibrous batting consists essentially of fibers having a thermal conductivity less than 50 mW/m-K.

6. The composite of Claim 1, wherein the lofty batting has a sufficient quantity of fibers in its z axis to provide loft yet not so many that the insulating properties of the composite are compromised by the z axis fibers acting as thermal conduits.

7. The composite of Claim 1, further comprising a finely dispersed dopant

in an amount sufficient to improve the thermal performance at high temperature of the composite.

8. The composite of Claim 7, wherein the dopant is selected from the group consisting of carbon black, titania, iron oxides, silicon carbide, molybdenum silicide, manganese oxides, and polydialkylsiloxanes wherein the alkyl groups contain 1 to 4 carbon atoms.

9. The composite of Claim 7, wherein the dopant is present in an amount of about 1 to 20% by weight of the total weight of the composite.

10. The composite of Claim 1, wherein the cross-sectional area of the fibers of the batting visible in a cross-section of the composite is less than less than 8% of the total surface area of that cross section.

11. The composite of Claim 1, wherein the fibers making up the lofty fibrous batting have a diameter of about 0.1 to 100 μm and are crimped fibers evenly dispersed throughout the composite.

12. A composite article comprising aerogel and a reinforcing structure to serve as a flexible, durable, light-weight insulation product wherein the reinforcing structure comprises a fibrous batting which is sufficiently lofty that the cross-sectional area of the fibers of the batting visible in a cross-section of the composite is less than less than 10% of the total surface area of that cross section.

13. The composite of Claim 12, wherein the aerogel is selected from the group consisting of inorganic and organic gel forming materials.

14. The composite of Claim 12, wherein the inorganic gel forming material is selected from the group consisting of zirconia, yttria, hafnia, alumina, titania, ceria, and silica, and any combination thereof.

15. The composite of Claim 12, wherein the batting is compressible by a minimum of 50 % of its thickness and is sufficiently resilient that after compression for about 5 seconds it returns to at least 70% of its original thickness.

16. The composite of Claim 15, wherein the batting is compressible by at least 65% of its thickness and is sufficiently resilient that after compression for about 5 seconds it returns to at least 75% of its original thickness.

17. The composite of Claim 12, wherein the batting has a density in the range of about 0.1 to 16 lbs/ft³ (0.001-0.4 g/cc), is compressible by at least 65% of its thickness and is sufficiently resilient that after compression for about 5 seconds it returns to at least 75% of its original thickness.

18. The composite of Claim 12, wherein the batting has a density of about 2.44 to 6.1 lbs/ft³ (0.04 to 0.1 g/cc).

✓ 19. A composite article comprising aerogel and a reinforcing structure to serve as a flexible, durable, light-weight insulation product wherein the reinforcing structure comprises (i) a lofty fibrous batting which causes no substantial degradation of the thermal performance of the aerogel as compared with a non-reinforced aerogel body of the same material and (ii) microfibers having diameters from about 0.1 to 100 μm and aspect ratios greater than 5.

20. The composite of Claim 19, wherein the microfibers are comprised of a material having a thermal conductivity below about 200 mW/m-K.

21. The composite of Claim 19, wherein the microfibers are comprised of a material that resists sintering more than the lofty fibrous batting.

22. The composite of Claim 19, wherein the microfibers are comprised of a material that reduces the transmission of infrared radiation through the composite

more than the lofty fibrous batting.

23. The composite of Claim 19, wherein the microfibers are comprised of a material that attenuates radio frequency waves.

24. The composite of Claim 19, wherein the microfibers are comprised of one or more materials that attenuate electromagnetic waves.

25. The composite of Claim 19, wherein the microfibers are selected from the group consisting of carbon fibers and copper fibers.

26. The composite of Claim 19, wherein at least one of the following properties varies within spatial locations of the composite: microfiber material; microfiber size; microfiber aspect ratio; and microfiber quantity.

27. The composite of Claim 19, wherein a material having a high thermal conductivity equal to or greater than 1 W/m-k is added on the x-y axis of the composite structure in addition to the lofty batting.

28. The composite of Claim 27, wherein the high thermal conductivity material comprises a metal.

29. The composite of Claim 28, wherein the high thermal conductivity material is a metal which is sufficiently malleable to provide conformability to the composite to enable the composite to retain its shape after bending.

30. The composite of Claim 29, wherein the metal is selected from the group consisting of copper and steel.

31. The composite of Claim 27, wherein the high thermal conductivity material is in a porous form selected from the group consisting of mesh, sheet,

perforated sheet, foil, and perforated foil.

32. The composite of Claim 27, wherein the composite has an x-y horizontal plane and a z vertical plane and the thermally conductive materials are oriented in the x-y plane of the composite.

33. The composite of Claim 27, wherein the high thermal conductivity material conducts heat away from a localized heat load and emits it to the environment.

34. The composite of Claim 33, wherein the heat is emitted to the environment by means of a heat sink.

35. The composite of Claim 27, wherein the high thermal conductivity material conducts heat away from a localized heat load to a process which uses the thermal energy directly.

36. The composite of Claim 27, wherein the high thermal conductivity material conducts heat away from a localized heat load and into a device which converts the thermal energy to electrical energy.

37. The composite of Claim 27, wherein the high thermal conductivity material comprises carbon fibers.

38. A composite article comprising aerogel and a reinforcing structure to serve as a flexible, durable, light-weight insulation product wherein the reinforcing structure comprises (i) a lofty fibrous batting which causes no substantial degradation of the thermal performance of the aerogel as compared with a non-reinforced aerogel body of the same material and (ii) one or more high thermal conductivity materials having a thermal conductivity of equal to or greater than 1 W/m-k.

39. The composite of Claim 38, wherein the high thermal conductivity material comprises a metal.

40. The composite of Claim 38, wherein the high thermal conductivity material is a metal which is sufficiently malleable to provide conformability to the composite to enable the composite to retain its shape after bending.

41. The composite of Claim 40, wherein the metal is selected from the group consisting of copper and steel.

42. The composite of Claim 38, wherein the high thermal conductivity material is in a porous form selected from the group consisting of mesh, sheet, perforated sheet, foil, and perforated foil.

43. The composite of Claim 38, wherein the composite has an x-y horizontal plane and a z vertical plane and the high thermal conductivity material is oriented in the x-y plane of the composite.

44. The composite of Claim 38, wherein the high thermal conductivity material conducts heat away from a localized heat load and emits it to the environment.

45. The composite of Claim 44, wherein the heat is emitted to the environment by means of a heat sink.

46. The composite of Claim 38, wherein the high thermal conductivity material conducts heat away from a localized heat load to a process which uses the thermal energy directly.

47. The composite of Claim 38, wherein the high thermal conductivity material conducts heat away from a localized heat load and into a device which

converts the thermal energy to electrical energy.

48. The composite of Claim 38, wherein the high thermal conductivity material comprises carbon fibers.

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